# IRON ORES FROM RAJASTHAN, MAHARASHTRA, GOA, ANDHRA PRADESH, TAMIL NADU, ASSAM, KARNATAKA UTTAR PRADESH & NEPAL

## IRON ORES FROM RAJASTHAN

### 1. Daralmata Iron Ore

The sample was drawn from Nathara Ki-Pal deposits in Udapipur Dist. and was received through M/s. Kamani Engineering Co. Ltd. for beneficiation studies. The sample consisted of lumps ranging in size from 24 mm to 160 mm and had the following analysis :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 40.80 | P | 0.03 |
| $SiO_2$ | 40.37 | S | 0.13 |
| $Al_2O_3$ | 0.80 | LOI | 0.13 |
| MgO | 0.20 | | |

Microscopic examination of the sample indicated the presence of hematite and minor amounts of magnetite. Quartz followed by minor amount of mica and felsper formed the gangue and were liberated at 48 mesh size. Chemical analysis of sized protion obtained from 18 mm crushed sample indicated the seggregation of iron minerals in -100 mesh fines.

Tabling tests with -48 mesh ground sample after hydro-classification produced a combined concentrate analysing 65.8% Fe and 3.8% $SiO_2$ with 79.4% Fe distribution. Humphry's spiral test with -48 mesh feed yielded a concentrate assaying 61.73% Fe 11.7% $SiO_2$ with 61.0% Fe distribution in it. Spiral treatment followed by tabling of the spiral rejects at 48 mesh size produced a combined concentrate assaying 62.0% Fe and 10.2% $SiO_2$ with 84.7% Fe distribution in it.

High intensity magnetic separation tests yielded a concentrate assaying 60.45% Fe and 12.57% $SiO_2$ with 70.0% Fe distribution whereas reduction roast and magnetic separation produced a grade of 64.8% Fe and 8.37% $SiO_2$ with 90.0% Fe distribution in it.

High tension separation tests with deslimed 48 mesh feed produced a conducting concentrate assaying 64.59% and 6.0% $SiO_2$ with 72.4% Fe distribution.

Flotation tests with 77.8% -200 mesh feed using Sod. silicate and oleic acid emulsion yielded a grade of 63.37% Fe with 64.6% Fe distribution where as a floation test with 1.0 kg/tonne of pertroleum sulphonate and 2.0 kg/tonne of sulphuric acid, followed by one cleaning yielded a grade of 64.07% Fe and 8.13% $SiO_2$ with 82.3% Fe distribution.

### 2. Amsiwali Iron Ore

The sample was drawn from Amsiwali section of Nathra-Ki-Pal deposits and was similar to that of Daralmata sample. Complete chemical analysis of the sample was as under :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 49.85 | MgO | 0.20 |
| FeO | Trace | P | 0.02 |
| $SiO_2$ | 27.82 | S | 0.12 |
| $Al_2O_3$ | 0.38 | LOI | 0.60 |
| CaO | Trace | | |

The sample analysed more iron than Daralmata sample. Hematite and the gangue were liberated at 100 mesh size.

Tabling tests conduced with 48 and 65 mesh feed produced concentrates assaying 64.71% Fe with 81.8% Fe distribution and 67.0% Fe and 86.0% Fe distribution respectively. Combined spiral operation followed by cleaning of the spiral tails on table yielded a combined concentrate assaying 66.74% Fe with 85.6% Fe distribution in it.

Direct magnetic separation test at 65 mesh size produced a grade of 62.3% Fe with 85.3% Fe distribution where as a reduction roast followed by magnetic separation produced a grade of 66.73% with 98.2% Fe distribution. Electro-Static separation with sized feed yielded a combined (conducting) concentrate assaying 67.53% Fe with 67.2% Fe distribution.

Flotation tests employing 70% -200 mesh feed with 0.5 kg/tonne of sod. silicate and 0.36 kg oleic acid emulsion yielded concentrate assaying 62.1% Fe with 88.3% Fe distribution. This after one cleaning improved to 65.62% Fe with 85.8% Fe distribution ; use of petroleum sulphonate in place of oleic acid, yielded a grade of 60.4% Fe with 90.3% Fe distribution.

## MAHARASTRA ORES

### 1. Khursipar Iron Ore

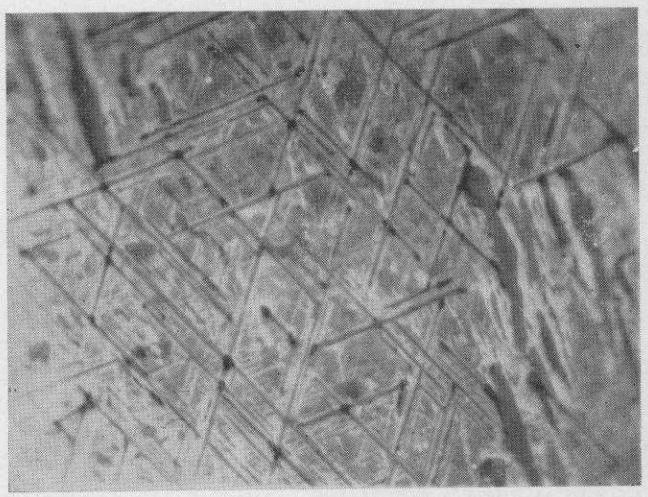
The sample was received from the State Directorate of Mining and Geology to reduce the $TiO_2$ content. The sample analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 55.70 | MgO | 0.70 |
| FeO | 6.50 | P | 0.009 |
| $SiO_2$ | 2.10 | S | 0.005 |
| $TiO_2$ | 15.11 | CaO | Trace |
| $Al_2O_3$ | 1.05 | $V_2O_3$ | Trace |

Microscopic examination indicated the presence of "Titano-hematite", Ilmenite, magnetite, goethite, lepidocrosite, chlorite, serpentine, quartz were the other minerals. Ilmenite was present as the exsolved intergroth in the cleavage planes of altered magnetite and was liberated at 65 mesh size.

Magnetic separation tests conducted at different sizes indicated that at 100 mesh size, the magnetic concentrate analysed 60.82% Fe and 9.38% $TiO_2$ with 79.5% Fe distribution.

Continuous magnetic separation tests conducted at 10 mesh followed by regrinding of the magnetic concentrate to 65 mesh and magnetic separation, produced a concentrate assaying 63.05% Fe and 9.9% $TiO_2$ with 71.1% Fe distribution in it. No other tests showed any improvement over these results.



Martilization of magnetite (light grey) to hematite (white) along the octahedral cleavage planes. Exsolved ilmenite (dark grey) seen occupying the octahedral cleavage planes of magnetite. Reflected Illumination. X700 oil. Titaniferous Iron Ore from Khursipar, Maharastra.

### 2. Surajghar Iron Ores

Three samples designated as Massive ore, float ore and laminated ore were received from State Government of Maharastra to undertake mineralogical studies and to determime the crushability and reducibility of the samples.

Mineralogical examination indicated the presence of hematite as the chief iron bearing mineral in association with small amounts of goethite. Some aluminous and siliceous minerals were also found in the laminated and float ores. Massive sample contained some relicts of magnetite also.

Massive iron ore lumps varied in crushing strength from 446 kg to 572 kg/sq. cm. with an average of 516 kg/sq. cm. Float ore had a variation of 546 kg to 960 kg/sq. cm. averaging to 639 kg/sq. cm. where as the laminated ore had a variation of 392 kg to 630 kg/sq. cm. with an average of 511 kg/sq. cm.

### 3. Lohara Iron Ore

Two samples designated as "Main ore body sample" and "Stack sample" were received from the Small scale industries corporation of Maharastra (SICOM) for their mineralogical and davis tube (High intensity magnetic separation) tests.

*Mineralogy*

Different types of lumps were found in the samples which may be categorised as i) Granular type, ii) hard massive type, iii) lenticular metallic type, iv) Gangue impregnated massive type and v) hydrated iron oxide type. Hematite was the chief mineral in all the types followed by magnetite, martite, and hydroxide minerals like goethite, ochre etc. Minor amounts quartz and argillaceous minerals were also present. Alteration of magnetite to hematite was also observed. Complete chemical analysis of the sample was as follows.

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 66.50 | $Al_2O_3$ | 0.60 |
| FeO | 6.30 | S | 0.23 |
| $Fe_2O_3$ | 74.00 | P | Trace |
| $Fe_3O_4$ | 20.20 | $TiO_2$ | 0.003 |
| $SiO_2$ | 0.74 | LOI | 0.66 |

Chemical analysis of the sized products from 25 mm crushed ore did not show any variation in iron content.

Davis tube (High intensity wet magnetic separation) tests conducted with the ROM sample at 48 mesh, 65 mesh and 100 mesh size at different intensities indicated the variation of iron content, in the magnetic concentrate from 66.4% Fe to 67.2% Fe with a maximum of 70% Fe distribution. Similar tests with $-25+6$ mm lumps crushed to 48 mesh, 65 mesh and 100 mesh sizes at different magnetic intensities yielded concentrates varying from 67.08% Fe to 67.87% Fe with a maximum distribution of 63% Fe.

*Stack Sample*

Complete Chemical analysis of the sample was as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 65.25 | $Al_2O_3$ | 1.20 |
| FeO | 7.20 | S | 0.092 |
| $Fe_2O_3$ | 69.20 | P | 0.028 |
| $Fe_3O_4$ | 23.20 | LOI | 0.210 |
| $SiO_2$ | 1.92 | $TiO_2$ | Trace |

Chemical analysis of the 25 mm crushed and sized portions varied from 66.3% Fe to 65.9% Fe.

Davis tube tests conducted with the R.O.M. sample at 48, 65 and 100 mesh sizes, yielded magnetic concentrates varying in chemical analysis from 67.34% Fe to 67.8% Fe. The non magnetics analysed 59.0% to 60.1% Fe.

Similar tests with $-25+6$ mm lumpy ore yielded magnetic concentrates varying from 67.0% Fe to 68.5% Fe where as the non-magnetic portions analysed from 58.46% Fe to 63.12% Fe.

## GOA IRON ORES

### 1. Pale Iron Ore

The sample was received from M/s. Chowgule & Co. and analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 60.50 | CaO | 0.19 |
| FeO | 2.55 | MgO | 0.37 |
| $SiO_2$ | 4.53 | S | 0.15 |
| $Al_2O_3$ | 3.91 | LOI | 4.47 |
| P | 0.07 | | |

The sample consisted of 10 mm fines. Examination of the sample under microscope revealed the presence of hematite as the chief ore mineral along with minor quantities of goethite and magnetite. Quartz was the gangue mineral in addition to clayey and ochery coating and was liberated at 20 mesh size.

As ochere, and silicates were the gangue, washing of the ore followed by cyclone treatment of the washing slimes were conducted. The ore was scrubbed in ball mill without fines and then sent to a spiral classifier where the sand and slimes were separated. The overflowing slimes were treated in a cyclone (33 mm vortex finder) with 11% solids in the feed. The cyclone under flow was collected and the over flow was rejected.

The washed sand analysed 64.7% Fe and 2.68% $SiO_2$ with 79.9% Fe distribution. The cyclone underflow analysed 61.88% Fe and 3.25% $SiO_2$ with 8.8% Fe distribution. The combined sand and cyclone underflow analysed 64.3% Fe, 2.76% $SiO_2$ and 2.25% $Al_2O_3$ with 93.6% Fe distribution.

Magnetic separation tests with $-10$ mesh crushed sample produced a magnetic concentrate assaying 67.13% Fe with 56.1% Fe distribution in it.

Pelletization tests were conducted with different grinds varying from 69% to 81% passing through 325 mesh screen. Test results indicated that 81% −325 mesh grind suited best for pellet making.

Pellets were prepared in a disc pelletizer of 1 meter dia and rotating at 24 r.p.m. The ore was fed to the pelletizer through a vibrating feeder and water was added through jets. The strength of the pellets was determined by testing their compression strength when they were wet, dry and heat hardened.

Pellets produced under the optimum conditions of 81% −325 mesh, with 7.76% moisture produced an average (20 pellets) compression strength of 1320 gm/pellet, for green pellets and 3028 gm/pellet when dry.

Heat hardening of the pellets was conducted in a feed box provided with special cast iron grate at the bottom and a burner on the top. The box along with the burner was placed over wind box connected to exahaust blower. The pellets were progressively fired to a max temperature of 1300°C over 60 minutes of time. The heat hardened pellets had a compression strength of 169.6 kg/pellet; 5.5% −10 mesh fines was produced after 1 hr. tumbling in a 180 mm × 200 mm drum, and 0.20% −6 mesh fines after four drops from 2 M. height on a steel plate. The pellets had a microporosity of 28%.

## 2. Sesa—Goa Iron Ore

The sample was received from M/s. Sesa Goa Ltd. and was designated as "Lateritic Iron ore in clayey matix". Complete analysis of the sample was as under:

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 55.50 | P | 0.04 |
| FeO | Trace | $TiO_2$ | 0.33 |
| $SiO_2$ | 2.72 | MgO | 0.45 |
| $Al_2O_3$ | 11.17 | Moisture | 1.10 |
| S | 0.20 | LOI | 6.90 |

The sample consisted upto 200 mm lumps with large quantity of fines and clayey matter. Mineralogical examination of the sample revealed the presence of hematite and goethite as predominant ore minerals and traces of pyrite and magnetite. Limonite, ochres, clay and quartz formed the gangue. Limonite, clay and ochere were deposited in the cracks and cavities present in the lumps.

The sample was stage crushed to 30 mm as per the flow-sheet given by M/s. Sesa Goa Ltd. and the crushed ore contained 16.0% −30+25 mm lumps and 15.2% of −10 mesh fines. The crushed ore was washed in a blade washer and wet screened on a double deck vibrating screen provided with 18 mm and 6 mm screens. The −6 mm material along with wash waters was treated in a spiral classifier which separated the sand and slimes; the −30+18 mm lumps analysed 61.6% Fe, 1.1% $SiO_2$ and 7.64% $Al_2O_3$ with 29.1% Fe distribution. The −18+6 mm lumps and −6 mm sand respectively analysed 56.9% Fe and 56.5% Fe with distributions of 31.3% Fe and 26.7% Fe.

Heavy media separation tests conducted with the washed −30+18 mm lumps produced a sink product at sp. gr. 3.0 assaying 63.3% Fe, 0.86% $SiO_2$ and 6.1% $Al_2O_3$ with 22.8% Fe distribution w.r.t. feed. Jigging tests with washed −18+6 mm lumps produced a concentrate assaying 62.7% Fe, 1.2% $SiO_2$ and 6.67% $Al_2O_3$ with 27.5% Fe distribution w.r.t. feed. Similar test with −6 mm washed sand produced a grade of 61.56% Fe with 19.0% Fe distribution in it.

The combined HMS and jig concentrates with washed products analysed 62.5% Fe, 1.26% $SiO_2$ and 6.6% $Al_2O_3$ with an over all recovery of 69.3% Fe in it. Further improvement in the Fe content may be possible at a finer size, but the stipulation laid by M/s. Sesa Goa Ltd. did not permit to do so.

## 3. Codli Iron Ores

Two low grade iron ore samples designated as lumpy ore and fines ore were received from M/s. Min Goa (P) Ltd. for pilot plant beneficiation.

Mineralogical studies on the samples indicated the presence of hydrated and anhydrous iron oxides together with lateritic matter and clay were present.

*Lumpy Ore*

The ore consisted of 100 mm lumps down to fines and analysed as under:

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 51.3 | MgO | Trace |
| FeO | Trace | Mn | Trace |
| $SiO_2$ | 5.0 | P | 0.08 |
| $Al_2O_3$ | 12.9 | LOI | 8.5 |
| CaO | Trace | | |

Washing of the ore after crushing to 30 mm size followed by screening on 10 mm screen produced +10 mm lumps assaying 53.2% Fe with 48.4% Fe distribution and −10 mm sand assaying 51.5% Fe with 35.3% Fe distribution in it. Heavy media separation tests at medium sp. gr. 2.9 produced a sink product assaying 59.3% Fe, 2.4% $SiO_2$ and 7.2% $Al_2O_3$. But the float product analysed 48.3% Fe.

The −10 mm sand was wet screened on 1 mm screen and the washed +1 mm sand analysed 50.4% Fe with 64.5% Fe distribution and the −1 mm sand analysed 56.0% Fe with 31.2% Fe distribution. HMS tests with the +1 mm sand at medium sp. gr. 2.8 yielded a grade of 61% Fe, 2.8% $SiO_2$ and 7.0% $Al_2O_3$.

A series of sizing and tabling tests conducted with −1 mm washed sand fraction indicated that after sizing at 65 mesh and tabling the combined concentrate analysed 65.8% Fe with 53.9% Fe distribution (Wrt −1 mm sand) in it.

Humphry's spiral tests with −1 mm sand after grinding to 28 mesh size produced a combined concentrate assaying 63.0% Fe with 54.9% Fe distribution.

Grinding of the −10 mm fines to 10 mesh followed by hydro-sizing and treatment on wilfly table produced a combined concentrate assaying 60.7% Fe with an additional Fe distribution of 1.8% Fe in it. Treatment of the slimes obtained from hydrosizing in cyclone yielded an underflow analysing 51.5% Fe.

*Fines Sample*

The fines sample consisted 100 mm lumps to fines and analysed as under :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 53.00 | MgO | 0.72 |
| FaO | 0.70 | Mn | Trace |
| $SiO_2$ | 6.90 | P | 0.057 |
| $Al_2O_3$ | 9.30 | LOI | 5.80 |
| CaO | Trace | | |

A representative portion of the rom was crushed to 30 mm and then washed in a log washer and then sized on 10 mm screen. The +10 mm lumps analysed 59.9% Fe with 25.1% Fe distribution and the −10 mm fines analysed 57.7% Fe with 42.8% Fe distribution in it.

HMS tests at sp. gr. 2.9 with the washed lumps yielded a sink product assaying, 63.4% Fe and the float product analysed 56.3% Fe.

Wet screening of the −10 mm fines on 1 mm screen produced coarser portion assaying 54.8% Fe and a fines portion assaying 61.3% Fe. Further HMS tests at sp. gr. 2.9 with +1 mm fines produced a grade of 59.9% Fe.

Tabling tests with −1 mm sand after sizing on different screens indicated that after an ideal sizing of on 48 mesh screen produced a combined concentrate assaying 66.2% Fe 1.61% $SiO_2$ and 2.1% $Al_2O_3$ with a total of 74.0% Fe distribution in it. Spiral test with −1 mm fines portion yielded a concentrate assaying 66.1% Fe, 1.0% $SiO_2$ and 2.4% $Al_2O_3$ with 61.7% Fe distribution in it. When the −10 mm washed sand was ground to 48 mesh size followed by tabling yielded a grade of 64.7% Fe with 62.6 Fe distribution. The slimes obtained after grinding when treated in a cyclone, the underflow analysed 51.8% Fe. Finally the flow sheet recommended was crushing the lumps to 10 mm washing and heavy media separation of −30+10 mm lumps ; the −10 mm cl. sand was to be ground and tabling at −14 mesh to be done.

### 4. Codli Iron Ores

Two samples marked as high grade lumpy ore and high grade fines were received for pilot plant beneficiation ; the samples analysed as under.

| | ASSAY % | |
|---|---|---|
| Constituent | Lumpy Ore | Fines |
| Fe | 57.40 | 61.60 |
| FeO | 0.80 | 2.80 |
| $SiO_2$ | 3.50 | 3.30 |
| $Al_2O_3$ | 6.90 | 4.50 |
| MgO | 0.57 | Trace |
| Mn | — | Trace |
| P | 0.036 | 0.045 |
| LOI | 6.70 | 4.20 |

Crushing to 30 mm followed by washing and sizing on 10 mm screen, the lumpy ore produced +10 mm lumps assaying 59.9% Fe, 2.1% $SiO_2$ and 6.5% $Al_2O_3$ with 38.0% Fe distribution and

−10 mm sand analysing 58.8% Fe, 3.1% $SiO_2$ and 6.4% $Al_2O_3$ with 38.2% Fe distribution. Similar products from the fines ore analysed respectively 63.5% Fe, 2.5% $SiO_2$ 3.0% $Al_2O_3$ with 22.7% Fe distribution and 63.3% Fe, 2.8% $SiO_2$ and 3.2% $Al_2O_3$ with 43.7% Fe distribution in it.

Lumpy and fine washed +10 mm products when treated by heavy media separation at sp. gr. 2.9 the bulk products respectively analysed 62.1% Fe, 1.8% $SiO_2$ and 5.8% $Al_2O_3$, and 64.9% Fe, 1.5% $SiO_2$ and 2.0% $Al_2O_3$.

When the −10 mm sand was wet screened on 1 mm screen the coarse fraction obtained from lumpy ore analysed 56.0% Fe and the finer sand analysed 63.0% Fe.

Similar tests with finer ore produced a coarse sand analysing 63.4% Fe and the fine sand assaying 64.4% Fe.

Further treatment of the +1 mm coarse sand by heavy media separation at sp. gr. 2.9 yielded sink products from lumpy and fine ore respectively analysing 60.5% Fe, 2.3% $SiO_2$ and 6.0% $Al_2O_3$ and 64.7% Fe, 1.8% $SiO_2$ and 2.2% $Al_2O_3$. Spiraling tests with −1 mm sand after grinding to 28 mesh produced a concentrate containing 65.4% Fe, 1.5% $SiO_2$ and 2.9% $Al_2O_3$ from lumpy ore. Similar concentrate obtained from fines analysed 65.7% Fe, 1.6% $SiO_2$ and 1.0% $Al_2O_3$ with 69% and 78.3% Fe distribution.

Cyclone tests with the washing slimes produced an underflow assaying 61.9% Fe from the lumpy ore and 61.6% Fe from the fine ore.

## MAGNETITE RECEIVED FROM BHARAT COKING COAL LTD.

The sample was received to produce a magnetite concentrate with 95% purity. The sample consisted of 60 to 70 mm lumps and analysed 59.48% Fe.

Tabling tests at −48 mesh and 65 mesh sizes produced concentrates assaying 68.13% Fe and 69.23% Fe. The Fe distribution was respectively 84.7% and 79.1%.

High intensity wet magnetic separation tests conducted at −48, −65 and −100 mesh sizes produced concentrates assaying 69.52% Fe, 70.1% Fe and 70.17% Fe respectively, with iron distributions varied from 90.2% with 48 mesh to 82.1% with 100 mesh feed. It was concluded that 65 mesh grind was suitable as the grade was 70.1% Fe with 88.3% Fe distribution in it.

This magnetite concentrate is to be used as a medium for separation of coal in coal washeries after making it as a suspension mixed in water to proper dilution.

## NEPAL IRON ORES

Two Iron ore samples designated as "upper bench ore" and "Lower bench ore" were received from Nepal Bureau of Mines.

### 1. Upper Bench Ores

The sample analysed as under :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 58.00 | MgO | 1.85 |
| FeO | 0.18 | S | 0.05 |
| $SiO_2$ | 10.00 | P | 0.04 |
| $Al_2O_3$ | 3.60 | LOI | 0.70 |
| CaO | 0.95 | | |

Mineralogical studies indicated the presence of hematite in abundance followed by minor amounts of goethite and ochers material. Quartz formed the gangue which would be liberated at about 20-30 microns size.

Washing tests at 40 mm size did not improve the grade. Similar tests at 20 mm also showed only marginal improvement. Hydroclassification and tabling tests at 48 mesh and 65 mesh sizes produced concentrates assaying 61.6% Fe with 60.6% Fe distribution and 62.2% Fe with 56.9% Fe distribution respectively. High intensity magnetic separation tests did not produce any encouraging results.

### 2. Lower Bench Ore

The sample had the following chemical analysis.

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 53.00 | MgO | 1.08 |
| FeO | 0.20 | S | 0.046 |
| $SiO_2$ | 15.88 | P | 0.035 |
| $Al_2O_3$ | 5.36 | LOI | 0.58 |
| CaO | 1.12 | | |

Washing tests at 40 mm and 20 mm showed only marginal improvement in the grade. Tabling

tests at 48 and 65 mesh produced concentrates assaying 59.5% Fe with 59.6% Fe distribution and 60.1% Fe with 55.8% Fe distribution in it.

From the above tests it may be seen that due to the very fine interlocking of Quartz with the iron minerals in the samples the concentrates produced could not have either very high grade or high recovery. The concentrate obtained with the Upper bench sample by tabling at −65 mesh assayed 62.2% Fe and 3.8% $SiO_2$ with a recovery of only 57.9% Fe. This concentrate satisfied the specification laid down by the sponsors. The concentrate of the lower bench sample after tabling was of lower grade.

High intensity magnetic separation could not produce any good concentrates with both the samples.

## ANDHRA PRADESH IRON ORES

### 1. Ongole Iron Ore

The sample was received from the State department of Mining and Geology for beneficiation and had the following analysis :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 31.60 | CaO | 0.54 |
| FeO | 5.40 | MgO | 0.30 |
| $Fe_2O_3$ | 27.80 | $TiO_2$ | Nil |
| $Fe_3O_4$ | 17.40 | P | 0.062 |
| $SiO_2$ | 49.90 | S | 0.052 |
| $Al_2O_3$ | 2.20 | LOI | 1.15 |

Mineralogical examination of the sample indicate the presence martite, magnetite, hematite, goethite and limonite. Quartz, grunerite, felspars and chlorite formed the gangue. The sample was concentrated by magnetic separation method.

Magnetic separation tests conducted with 48 mesh and 65 mesh feed produced magnetic concentrates assaying 54.8% Fe with 49.9% Fe distribution and 59.3% e with 74.3% Fe distribution respectively. Tabling test at 48 mesh size yielded a concentrate assaying 63.8% Fe with 51.9% Fe distribution and with 65 mesh feed the concentrate assayed 65.9% Fe with 57.8% Fe distribution.

Magnetic separation followed by tabling of the non-magnetic tailing at 100 mesh size yielded a combined concentrate assaying 62.42% Fe with 73.4% Fe distribution. Magnetic separation followed by cyclone treatment of non-magnetic tailing produced a combined concentrate assaying 63.93% Fe, with 83.4% Fe distribution.

Magnetic separation followed by reduction roast and magnetic separation with non magnetic tails at —100 mesh size produced a combined concentrate assaying 65.5% Fe with 82.0% Fe distribution. Direct reduction roast and magnetic separation tests at 100 mesh size produced a concentrate assaying 64.7% Fe with 80.9% Fe distribution in it.

*Sintering and Pelletization of Ongole Magnetite Concentrate*

The magnetite concentrate analysed as given below :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 64.68 | CaO | 0.56 |
| FeO | 15.80 | MgO | 0.50 |
| $SiO_2$ | 6.52 | S | 0.04 |
| $Al_2O_3$ | 1.02 | P | 0.05 |
| | | LOI | 0.50 |

The lime-stone sample used for sintering analysed 49.5% CaO, 3.35% MgO, 4.08% $SiO_2$ and 1.92% $Al_2O_3$ while the coke breeze analysed 63.7% F.C. 29.4% Ash, 5.7% Volatiles and 1.2% moisture.

Batch sintering tests indicated that 7.0% water, 5.0% coke and 25.0% return fines were optimum for the sinters. Self fluxing sinters upto a basicity of 2.0 were produced but 1.5 basicity sinters exhibited best shatter stability with less amount of fines.

Pelletization tests conducted with feeds ground to 67.5% to 94.0% —200 mesh. Tests indicated that a grind of 87.5% −200 mesh with 1% bentonite and 5.0% limestone produced pellets which had good green strength and drop resistance and after heat hardening yielded good quality strong fired pellets fully satisfactory from the point of view of chemical composition and physical properties. The firing temperature was 1300°C. The compressive strength was 250 kg in case of 1% benetonite and 5% limestone. These pellets after firing analysed Fe=62.2%, FeO=2.16%, $SiO_2$=6.4%, $Al_2O_3$=1.7%, CaO=2.0% and MgO=0.45%.

## TAMIL NADU IRON ORES

### 1. Salem Magnetite No. 1

The sample consisting 100 mm to fines was received from the Asst. Director of Industries and Commerce, Madras for beneficiation studies and analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 36.5 | CaO | 1.8 |
| FeO | 5.04 | MgO | 0.9 |
| $SiO_2$ | 44.2 | $TiO_2$ | 0.2 |
| $Al_2O_3$ | 1.92 | P | 0.09 |
| | | LOI | 0.20 |

Mineralogical examination of the sample indicated the presence of magnetite, hematite and goethite in a matrix of quartz followed by kynamite, sillimanite and mica. Metallics were fairly liberated at 48 mesh size.

Dry magnetic separation tests conducted with 35 mesh and 48 mesh feed produced magnetic concentrate assaying 60.34% Fe with 71.9% Fe distribution in it. Wet magnetic separation tests at 48 mesh and 65 mesh size yielded concentrates assaying 62.5% Fe and 64.3% Fe with 88.9% Fe and 83.6% Fe distribution respectively.

Rougher magnetic separation at 10 mesh size followed by grinding the magnetic conc. to 48 mesh and magnetic separation yielded a concentrate assaying 63.0% Fe with 83.5% Fe distribution.

Tabling tests with 48 mesh sized feed produced a combined concentrate assaying 65.2% Fe with 85.8% Fe distribution in it. Humphry's spiral tests yielded a concentrate assaying 62.0% Fe with 73.3% Fe distribution in it.

Pilot plant tests with 48 mesh (63% −100 mesh) on tables yielded a concentrate assaying 67.0% Fe with 77.6% Fe distribution while the magnetic separation tests with 68.0% —100 mesh feed produced a concentrate assaying 62.1% Fe with 81.2% Fe distribution in it.

### 2. Sintering of Salem magnetite

The magnetite concentrate received for sintering was of 65 mesh size (45.2% —200 mesh) and analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 62.1 | MgO | 0.70 |
| FeO | 13.1 | S | 0.35 |
| $SiO_2$ | 13.2 | P | 0.08 |
| $Al_2O_3$ | 1.12 | | |
| CaO | 1.0 | | |

Self fluxing sinters produced under the optimum conditions of 0.85 basicity ($CaO+MgO/SiO_2+Al_2O_3$), 7.0% coke and 9.0% water contents had the best shatter stability and analysed 53.68% Fe, 25.12% FeO and 13.25% $SiO_2$.

### 3- Salem Magnetite No. 2

About 160 tonnes of low grade magnetite ore consisting of 36 mm lumps to fines was received for pilot plant beneficiation studies analysed as below :

| Constitqent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 36.51 | CaO | 1.17 |
| $SiO_2$ | 44.88 | MgO | 1.77 |
| $Al_2O_3$ | 1.35 | P | 1.10 |

Microscopic examination revealed the presence of magnetite, hematite and goethite in the matrix of quartz, and ferruginous amphiboles. The metallics were liberated at 65 mesh size.

Batch magnetic separation tests indicated that 65 mesh grind was optimum for magnetic separation at which the concentrate analysed 64% Fe with 86.3% Fe distribution in it.

Continuous pilot plant tests were conducted with ore. The ore was ground in a closed circuit mall mill to 65 mesh size (88.7% −200 mesh) and then subjected to magnetic separation on a drum type electromagnetic separator. The non-magnetic tailings were further treated on shaking tables to recover the non-magnetic minerals. The magnetic concentrate analysed 66.8% Fe. The combined concentrate analysed 65.64% Fe with 91.5% Fe distribution in it.

Further cleaning of the magnetic concentrate produced a grade of 70.4% Fe with a distribution of 88.8% Fe w.r.t. feed.

### 4. Salem Magnetite No. 3

The sample was received from the Government

of Tamil Nadu at the instance of M/s. M. N. Dastur & Co., to produce a higher grade cons. The ore consisted of lumps ranging from 36 mm to 12 mm with little fines and analysed as below :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 37.0 | CaO | 0.2 |
| $SiO_2$ | 47.0 | MgO | 1.0 |
| $Al_2O_3$ | 0.8 | P | 0.067 |

Mineralogical examination of the sample indicated the presence of magnetite followed by hematite and goethite which were liberated from the silica matrix at 100 mesh size.

The ore was crushed in an open circuit rod mill to pass 65 mesh screen (87.3% −100 mesh) and then treated in a drum type wet magnetic separator. The non-magnetic tailings were cleaned on a shaking table to recover hematite and goethite portions. The combined magnetic and table concentrate analysed 67.5% Fe and 5.49% insol., with a Fe distribution of 88% in it. These results were quite comparable with those obtained with earlier sample.

### 5. Kavuthimalai Magnetite (Sample C)

The sample consisting 25 to 50 mm lumps was received from the State department of mining and geology for beneficiation. Complete chemical analysis of the sample was as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 34.60 | $SiO_2$ | 43.57 |
| FeO | 4.47 | S | 0.36 |
| $Fe_2O_3$ | 43.76 | P | 0.10 |
| $Al_2O_3$ | 1.00 | $TiO_2$ | 0.10 |

Wet magnetic separation tests conducted with 10 mesh sample produced a concentrate assaying 44.25% Fe with 95.82% Fe distribution. When the inntensity was slightly increased, the concentrate analysed 41.81% Fe but the distribution improved to 97.15%. Further cleaning of the concentrate at 65 mesh size improved the grade to 64.9% Fe with 91.36% distribution in it.

Straight wet magnetic separation tests conducted at 48, 65 and 100 mesh size yielded respectively concentrates assaying 61.5% Fe, with 94.04% Fe distribution, 63.4% Fe with 93.27% Fe distribution and 64.3% Fe with 87.22% Fe distribution in them.

Wet magnetic separation test at 65 mesh size, followed by one cleaning yielded a concentrate assaying 68.4% Fe with 88.5% Fe distribution. Continuous wet magnetic separation at −10 mesh size followed by regrinding and cleaning at 65 mesh size produced a concentrate assaying 63.15% Fe with 91.43% Fe distribution in it.

Tabling tests with 35 mesh and 48 mesh feed produced concentrates assaying 63.2% Fe with 67.58% Fe distribution and 65.9% Fe with 57.15% Fe distribution in it. Humphery's spiral test with 48 mesh feed yielded a concentrate assaying 57.25% Fe with 81.38% Fe distribution in it.

Dry magnetic separation tests with 10 mesh feed followed by regrinding to 65 mesh and one cleaning produced a grade of 58.58% Fe in it.

### 6. Mgnetite from Kavuthimalai (M)

The sample was received from the Tamil Nadu State, Department of Mining and Geology and analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 34.51 | $SiO_2$ | 45.97 |
| FeO | 5.69 | S | 0.345 |
| $Fe_2O_3$ | 42.56 | P | 0.100 |
| $Al_2O_3$ | 1.05 | $TiO_2$ | 0.095 |

Mineralogical examination revealed the presence of martite, magnetite and minor amounts of maghemite, hydro-hematite, hydro goethite and ochre. Quartz followed by small amounts of grunerite, tremolite and garnet formed the non-metallic gangue. The metallics were fairly liberated at 65 mesh size.

Rougher magnetic separation tests with 10 mesh feed at an intensity of 3000 gauss produced a concentrate assaying 45.3% Fe with 91.16% Fe distribution in it.

Direct magnetic separation tests at 48,65, and 100 mesh respectively yielded concentrates assaying 58.2% Fe with 94.4% Fe distribution, 63.03% Fe with 93.14% Fe distribution and 64.4% Fe with 91.44% Fe distribution in it.

Wet magnetic separation at 65 mesh followed by one cleaning yielded a concentrate assaying 65.37% Fe with 90.92% Fe distribution in it.

Continuous magnetic separation tests with 10

mesh sample followed by regrinding to 65 mesh and clearing yielded a concentrate assaying 64.59% Fe with 85.5% Fe distribution. Similar tests with 65 mesh feed and one cleaning yielded a concentrate assaying 66.06% Fe with 85.18% Fe distribution in it.

Roughing at -10 mesh followed by regrinding and cleaning at 65 mesh size in a magnetic separator produced a concentrate assaying 62.58% Fe and 88.39% Fe distribution in it. Tabling tests at 65 mesh yielded a concentrate assaying 65.52% Fe with 62.65% Fe distribution in it.

### 7. Magnetite from Kavuthimalai (F)

The sample was the third received from the State Mining and Geology Department from Kavuthimalai area. The sample analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 31.63 | $SiO_2$ | 48.00 |
| FeO | 2.23 | S | 0.26 |
| $Fe_2O_3$ | 42.39 | P | 0.091 |
| $Al_2O_3$ | 1.38 | $TiO_2$ | 0.092 |

Microscopic examination of the sample revealed the presence of martite, magnetite, maghemite, and minor amounts of pyrite, marcasite, hydrogoethite and hydro-hematite. Quartz followed by minor amounts of grunerite, tremolite, garnet and apatite formed the gangue. Metallics were fairly liberated at -100 mesh size.

Wet magnetic separation at 10 mesh size produced a concentrate assaying 36.92% Fe with 94.92% Fe distribution. This concentrate after regrinding and cleaning at 48 mesh and 65 mesh respectively produced 47.16% Fe grade with 92.14% Fe distribution and 56.10% Fe with 89.41% Fe distribution in it.

Straight magnetic separation tests conducted at 65, 100 and 150 mesh size produced concentrates assaying 56.03% Fe, 62.75% Fe and 63.80% Fe with 92.11% Fe 91.26% Fe and 84.72% Fe distribution respectively. The concentrate obtained at 100 mesh size after one cleaning analysed 63.7% with 88.55% Fe distribution in it.

Continuous wet magnetic separation at 35 mesh size followed by regrinding and cleaning at 100 mesh size analysed 63.43% Fe with 86.23% Fe distribution in it. Recleaning at -150 mesh size analysed 64.85% Fe with 85.09 Fe distribution.

Tabling at −35 mesh size followed by regrinding to 100 mesh and one cleaning produced a grade of 63.5% Fe with 44.18% distribution in it. Magnetic separation at 10 mesh size followed by grinding to 100 mesh and one cleaning produced a concentrate assaying 64.23% Fe with 82.85% Fe distribution in it.

## ASSAM IRON ORES

### 1. Sample from Goalpara

The sample was received from the State Directorate of Mining and Geology, Shillong was drawn from Golpara Area. The sample in its as received state contained 12−75 mm lumps and analysed as below :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 46.45 | CaO | 0.22 |
| FeO | 4.41 | MgO | 0.60 |
| $SiO_2$ | 32.00 | S | 0.16 |
| $Al_2O_3$ | 0.60 | P | 0.073 |

Mineralogical examination of the sample indicated the presence of hematite and quartz and ferromagnesium minerals as gangue. Metallics were liberated at 48 mesh size.

Tabling tests at 48 mesh size produced a concentrate assaying 66.3% Fe with 89.6% Fe distribution in it.

When the test was conducted at 48 mesh size, after sizing, the combined concentrate analysed 66.89% Fe with 89.3% Fe distribution in it.

Humphrey's spiral test at 48 mesh size followed by the treatment of spiral tails on shaking table produced a grade of 64.4% Fe with 89.2% Fe distribution. Similar test with sized feed produced a combined concentrate assaying 66.83% Fe with 91.9% Fe distribution.

High tension separation tests with closely sized −48 mesh material produced a combined concentrate assaying 67.70% Fe with 42.6% Fe distribution. Flotation tests conducted with 42.6% Fe −200 mesh feed with 3.0 Kg./tonne sulphuric acid and 0.75 Kg/tonne petroleum sulphonate per tonne each produced a concentrate assaying 66.21% Fe with 79.4% Fe distribution. Cationic

floatation tests with 1.0 Kg. starch and 0.3 Kg. Aeromine 317 per tonne produced a concentrate (tailing) assaying 67.4% Fe with 93.4% Fe distribution.

### 2. Chandradinga (Assam) Iron Ores

The sample received for beneficiation and agglomeration studies from the Assam State Geology Department consisted of lumps from 200 mm to 25 mm and analysed as under :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 44.24 | MgO | 0.08 |
| FeO | 2.52 | S | 0.041 |
| $SiO_2$ | 32.42 | P | 0.414 |
| $Al_2O_3$ | 1.71 | LOI | 3.10 |
| CaO | 0.22 | $TiO_2$ | Trace |

Microscopic studies of the sample revealed the presence of martitized magnetite and hematite with traces of goethite being the chief metallic minerals while quartz and amphiboles formed the gangue.

Representative sample was crushed to 28, 35, 48 and 65 mesh sizes and treated on Wilfley table. The concentrates analysed from 62.72% Fe in case of 28 and 35 mesh grinds and 63.96% Fe and 64.52% Fe with 48 mesh and 65 mesh grinds. The Fe distributions were 77.9%, 82.0%, 81.6% and 79.0% respectively for the coarsest to finest grinds.

Humphrey's spiral test with 48 mesh feed yielded a concentrate assaying 62.71% Fe with 77.1% Fe distribution.

Wet magnetic separation tests at 48 and 65 mesh size yielded 61.94% Fe and 61.48% Fe grade but the recoveries were 35.38% Fe only and very poor. Sulphonate and fatty acid flotation tests could produce concentrate assaying only 50.98% Fe with 73.3% Fe recovery and is not of any acceptable grade.

Pellets were prepared from the 48 mesh table concentrate having the following analysis.

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 63.96 | CaO | 0.35 |
| FeO | 2.88 | MgO | 0.12 |
| $SiO_2$ | 7.56 | S | 0.035 |
| $Al_2O_3$ | 1.56 | P | 0.06 |

A series of batch pelletization tests indicated that good pellets may be produced with a feed of 70% −325 mesh using 1% bentonite and 8% limestone. These pellets had a compression strength of 325 kg/pellet after heat hardening.

*Reducibility Tests*

Reducibility studies were conducted on heat hardened magnetite pellets by bulk reducibility method (Gakushin Principle). Test results indicated better reduction behaviour showing 42.5% reducibility as well as lowest reducibility of 2.5% among the various pellets tested. All samples withstood high temperature degradation and no appreciable fines were seen after reduction.

## KARNATAKA IRON ORES

### 1. Kudremukh Ore No. 1

The sample was received from M/s. NMDC Ltd., and consisted of 200 mm lumps to fines with the following analysis :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 42.17 | P | 0.027 |
| FeO | 4.34 | MgO | 0.343 |
| $SiO_2$ | 36.30 | CaO | Trace |
| $Al_2O_3$ | 1.06 | LOI | 2.710 |
| S | 0.074 | | |

Mineralogical examination of the sample indicated the presence of hematite, magnetite and goethite. Quartz followed by felspar, tremotile etc. formed the gangue.

Tabling tests with sized 48 mesh feed produced a combined concentrate assaying 63.66% Fe with 74.7% Fe distribution. Tabling with 100 mesh feed produced a concentrate assaying 63.62% Fe with 62.1% Fe distribution. Treatment of 48 mesh feed in Humphrey's spiral produced a concentrate of 59.8% Fe with only 46.7% Fe distribution and treatment of the spiral tails on shaking table yielded a grade of 62.2% Fe with an additional 25.2% Fe distribution. The combined spiral and table concentrate analysed 60.63% Fe with 73.2% Fe distribution.

Magnetic separation at 65 and 100 mesh sizes respectively yielded a grade of 62.77% Fe and 64.57% Fe but the recoveries were only 49.3% and 45.5% Fe.

Flotation tests employing a grind of 76% −200 mesh with 3.5 Kg. $H_2So_4$ and 1.25 Kg. Petroleum sulphonate each per tonne yielded a concentrate assaying 62.2% Fe and 8.75% $Sio_2$ with 88.5% Fe distribution. After one cleaning the grade of the concentrate improved to 63.8% Fe and 5.8% $SiO_2$ with 87.5% Fe distribution.

Wet magnetic separation with 76% −200 mesh grind followed by flotation and one cleaning of the non-magnetic tails produced a combined concentrate assaying 62.9% Fe, and 6.2% $SiO_2$ with 90.1% Fe distribution in it.

## 2. Donimali Iron Ores

Five different samples were received from M/s. NMDC Ltd. at the instance of MECON from the Donimali deposits in Karnataka State. All the samples were washed after reducing the size to 30 mm. The washing slimes were treated in cyclone for further recovery of the iron ore fines.

Washing tests were conducted in a blade washer provided with water sprays. The washed ore along with the waters was discharged on to a double deck vibrating screen provided with 25 mm and 6.7 mm screens. The −6.7 mm fines and the wash-water were separated in a spiral classifier. The slime was further treated in hydrocyclone of 100 mm dia with 30 mm vortex finder.

The −6 mm sand obtained from the classifier was used for production of sinter using coke and coal fines and limestone by determining the optimum conditions.

Microscopic examination of the different samples indicated the presence of hydrohematite, goethite, magnetite, limonite, laterite, lepidocrosite in their order of abundance.

*a. Sample No. 1 Type 2*

Complete chemical analysis of the sample was as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 65.00 | MgO | Trace |
| FeO | Trace | S | 0.12 |
| $SiO_2$ | 1.90 | P | 0.10 |
| $Al_2O_3$ | 2.60 | LOI | 1.50 |
| CaO | 0.50 | | |

Washed −30+6.7 mm lumps represented 71.2% of the feed and analysed 67.5% Fe, 1.6% $SiO_2$ and 2.0% $Al_2O_3$ with 73.9% Fe distribution in them. The classifier sand analysed 66.1% Fe, 2.0% $SiO_2$ and 2.6% $Al_2O_3$ with 18.6% Fe distribution in it. The slimes analysing 46.8% Fe when treated in cyclone produced an underflow analysing 56.4% Fe with an additional Fe distribution of 4.5% in it. The combined classifier sand and the cyclone underflow analysed 63.9% Fe, 2.3% $SiO_2$ and 3.1% $Al_2O_3$ with 23.1% Fe distribution from it. 3.0% of total Fe was lost in the cyclone overflow slimes.

*b. Sample Type 3*

The sample analysed as under :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 66.00 | MgO | Trace |
| FeO | 1.10 | S | 0.08 |
| $SiO_2$ | 1.10 | P | 0.19 |
| $Al_2O_3$ | 2.60 | LOI | 1.70 |
| CaO | Trace | | |

After washing and sizing, the −30+6.7 mm lumps analysed 67.4% Fe, 0.8% $SiO_2$ and 1.6% $Al_2O_3$ with 61.0% Fe distribution in it. The sand analysed 66.0% Fe 1.2% $SiO_2$ and 2.1% $Al_2O_3$ with 29.6% Fe distribution in it. The slime analysing 57.1% Fe when treated in a cyclone produced an underflow product assaying 60.8% Fe with 5.4% Fe distribution in it. The combined sand and cyclone underflow analysed 63.8% Fe, 2.1% $SiO_2$ and 3.0% $Al_2O_3$ having a distribution of 35.0% Fe in it.

*c. Sample Type 4*

The sample had the following chemical analysis :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 64.70 | MgO | Trace |
| FeO | Trace | S | 0.04 |
| $SiO_2$ | 2.30 | P | 0.08 |
| $Al_2O_3$ | 2.80 | LOI | 2.40 |
| CaO | Trace | | |

Washing tests produced a grade of 66.9% Fe, 1.6% $SiO_2$ and 2.1% $Al_2O_3$ with 56.8% Fe distribution for the −30+6.7 mm lumps where as the −6.7 mm sand analysed 64.7% Fe, 2.1% $SiO_2$ and 2.6% $Al_2O_3$ with 28.6% Fe distribution in it. The slime analysing 57.1% Fe when treated in a cyclone produced an underflow product assay-

ing 61.1% Fe, with 8.8% Fe distribution. The combined sand and cyclone product analysed 63.8% Fe, 2.1% $SiO_2$ and 3.0% $Al_2O_3$ with 37.4% Fe distribution in it.

*d. Sample Type 5*

The sample analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 65.50 | MgO | Trace |
| FeO | 1.70 | S | 0.08 |
| $SiO_2$ | 2.10 | P | 0.09 |
| $Al_2O_3$ | 2.60 | LOI | 1.40 |
| CaO | Trace | | |

Washed lumps of −30 + 6.7 mm size analysed 68.1% Fe, 1.1% $SiO_2$ and 1.7% $Al_2O_3$ with 46.6% Fe distribution in it. The classifier sand of −6.7 mm size analysed 67.5% Fe, 1.8% $SiO_2$ and 2.2% $Al_2O_3$ with 36.2% Fe distribution in it. The slimes analysing 57.1% Fe when treated in cyclone, produced an underflow assaying 60.7% Fe, with 11.2% Fe distribution in it. The combined sand and cyclone products analysed 65.8% Fe, 2.16% $SiO_2$ and 2.83% $Al_2O_3$ having a total distribution of 47.4% Fe in it.

*e. Sample Type 6*

Complete chemical analysis of the sample was as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 65.80 | MgO | Trace |
| FeO | Trace | S | 0.07 |
| $SiO_2$ | 1.80 | P | 0.08 |
| $Al_2O_3$ | 2.20 | LOI | 1.50 |
| CaO | Trace | | |

The sample was more blue dust type in nature and contained a large quantity of fines. Washed −30 + 6.7 mm lumps analysed 66.7% Fe, 1.4% $SiO_2$ and 1.9% $Al_2O_3$ with 20.5% Fe distribution. The classifier sand representing 55% of the feed analysed 66.6% Fe, 1.5% $SiO_2$ and 1.8% $Al_2O_3$ with 55.9% Fe distribution in it. The classifier overflow analysed 62.5% and when treated in cyclone, produced an underflow assaying 65.1% Fe with 12.4% Fe distribution in it. The total Fe loss in the slimes was 11.2% only. The combined sand and cyclone underflow analysed 66.3% Fe, 1.56% $SiO_2$ and 2.0% $Al_2O_3$ with 68.3% Fe distribution in it.

Sintering tests were conducted with the combined sand and cyclone underflow produced under varying conditions. Sinter suitable for charging in the blast furnace has produced from the type 6 sample only. Sinters produced from the other types were having low strength. Fluxed sinters were also produced.

Use of double layer of coke helped in producing good quality of sinters from the types 2, 3, 4, & 5. When 20% of the coke was replaced by coal, except No. 4, the rest of the type samples produced good quality sinters.

Crushing strength for the various types of ore pieces was determined which varied from 202 kg/sq. cm. in case of blue dust type lumps, to 1838.1 kg/sq. cm. in case of massive laminated type lumps.

### 3. Sintering of Hospet Iron Ore fines

The sample consisted of 200 mm lumps to fines in its as received state from the Mineral & Metals Trading Corporation. The ore originally contained 5.1% of 12.5 mm fines which increased to 9.2% when the ore was crushed to 75 mm size. The original —12.5 mm fines analysed 49.27% Fe while those produced during crushing analysed 67.2% Fe. It was decided by the sponsors to take up sintering study on the fresh fiines only.

Fludust from HSL, Rourkela, Limestone and coke of M/s. TISCO were used for sintering. The ore fines used in sintering analysed as follows :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 67.20 | CaO | 1.34 |
| $SiO_2$ | 1.24 | MgO | Trace |
| $Al_3O_2$ | 2.00 | LOI | 1.10 |

The coke analysed 25.7% ash, the limestone analysed 46.96% CaO and the fluedust analysed 24.8% Fe and 28.37% F.C.

Sinters were produced varying the water, coke return sinter fines and basicity. The best sinter was produced with 6% coke and 25% return fines ; self fluxing sinters of good quality were produced in the basicity range of 1.0 to 1.5.

## 4. Sintering of Iron Ore fines from MISL Bhadravati

The ore fines received from M/s. MISL, contained some lateritic material and analysed 58.94% Fe, 1.3% $SiO_2$ and 7.12% $Al_2O_3$. These fines were washed using an equal quantity of water. The washed sand analysed 60.76% Fe, 0.96% $SiO_2$ and 5.25% $Al_2O_2$ having a distribution of 78.2% Fe in it.

Coke analysing 25.07% ash from HSL, Bhilai and Limestone assaying 30.26% CaO and 14.84% MgO from MISL Bhadravati were used for sinter preparation.

7.0% Coke and 5.5% water for washed ore fines, and 9.0% coke and 5.5% water for unwashed fines were found to be optimum for the production of good quality sinters. Self-fluxing sinters having a basicity of 2.4 were also produced by adding high magnesia limestone to the sinter mix.

## 5. Pelletization of Donimalai Iron Ores Fines

Pelletization tests were undertaken on the fines from the composite sample received from M/s. NMDC Ltd. The ore had the following complete chemical analysis.

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 66.12 | CaO | 0.20 |
| $SiO_2$ | 1.60 | MgO | Trace |
| $Al_3O_2$ | 2.00 | | |
| S | 0.03 | Mn | Trace |
| P | 0.045 | LOI | 2.14 |

The ore consisted lumps upto 150 mm and was crushed to 30 mm size. The crushed ore was washed in a gravel washer and then screened on 6.7 mm screen. The washed lumps analysed 67.7% Fe and the sand analysed 66.4% Fe. The cyclone underflow from the slimes analysed 63.5% Fe. The combined cyclone underflow and classifier sand which formed the pelletization feed analysed 65.8% Fe, 1.9% $SiO_2$ and 2.3% $Al_2O_3$.

Pellets were prepared with dry ground feed to 65% to 85% −325 mesh size using bentonite as binder. Pellets having good green strength were produced, with 75% −325 mesh grind, 5-6% of moisture and 1% bentonite. The air-dried pellets were later heat hardened in a pot grate furnace having facilities for up and down drafts as well as gas and oil firings. The heat hardened pellets had a crushing strength of 237 Kg./pellet (Av). 500 kg. of heat hardned pellets were produced for testing at Hyl & Midrex Laboratories. The pellets analysed 63.1% Fe, 2.9% $SiO_2$ and 0.962% $Al_2O_3$ with traces of FeO.

## 6. Pelletization of Ku-dremukh Iron Ore Concentrate

5 Tonnes of magnetite concentrate was received from Kudremukh mines analysing as follows :—

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 67.90 | CaO | 0.08 |
| FeO | 19.20 | MgO | Trace |
| $SiO_2$ | 2.90 | S | 0.075 |
| $Al_2O_2$ | 1.00 | P | 0.027 |

The concentrate was of 28 mesh size. Preliminary pelletization tests indicated that 65% −325 mesh feed was quite sufficient and 0.5 to 1.0% of bentonite was essential to give a good compression strength for the green pellets. Further tests indicated that 85% of —325 mesh grind, 1% bentonite and 5 to 6% moisture were the optimum requirements where in the compression strength of the heat hardened pellet was 265 Kg/pellet. The heat hardened pellet had the following analysis :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 67.2 | $SiO_2$ | 3.1 |
| FeO | 0.5 | $Al_2O_2$ | 0.8 |

About 400 Kg heat hardened pellets were supplied to Hy L and Midrex Laboratories for solid state reduction tests.

## 7. Kemmangundi Iron Ore

*Pilot Plant Beneficiation and Sintering Studies*

The representative composite sample prepared by blending laminated, limonitic, lateritic and blue dust types analysed as under :

| Constituent | Assay % |
|---|---|
| Fe | 60.81 |
| $SiO_2$ | 1.65 |
| $Al_2O_2$ | 5.24 |

The sample was washed in a log washer after crushing to 50 mm and then sized on 12 mm and 6 mm screens. The 12 mm lumps analysed 63.2% Fe with 47.0% Fe distribution and the +6 mm lumps analysed 61.5% Fe with 12.7% Fe distribution. The —6 mm sand obtained after desliming analysed 60.9% Fe with 15.2% Fe distribution. Cyclone test with the slimes produced an underflow product analysing 59.2% Fe with 14.3% Fe distribution in it.

Direct wet screening tests with 50 mm crushed ore produced +12 mm lumps assaying 62.5% Fe with 53.6% Fe distribution and the combined +6 mm lumps and —6 mm classifier sand analysed 59.6% Fe with 32.4% Fe distribution in it.

Sintering tests were conducted with —12 mm material (including classifer sand) analysing 60% Fe, 1.7% $SiO_2$ and 5.3% $Al_2O_3$. The limestone received from Karnataka analysed 49.5% CaO, 3.35% MgO, 4.08% $SiO_2$ and 1.92% $Al_2O_3$. The coke breeze received from TISCO analysed 63.7% F.C. 29.4% ash, 5.7% volatiles and 1.2% moisture. Dolomite analysed 30.3% CaO, 23.2% MgO, 0.17% $SiO_2$ and 0.80% $Al_2O_3$. Another ingredient lime slugge analysed 48.6% CaO, 0.26% MgO, 10.6% $SiO_2$ and 0.85% $Al_2O_3$.

Preliminary tests indicated that 7.0% water, 6.0% Coke breeze and 25% return fines were found to be optimum.

Self fluxing sinters were prepared with varying basicity from 1.0 to 3.0 but slight increase in the coke content was needed to get proper sintering when the basicity was 2.0 and above.

## UTTAR PRADESH IRON ORES

### Girar Iron Ores, Jhansi District

Three iron ore samples designated as $C_1$, $B_1$ & $B_{11}$ were received from Director, State Mines & Geology Department. Government of U.P. Lucknow for beneficiation tests.

Microscopic examination of the samples indicated no difference in their mineralogical composition. Secondary hematite and magnetite were the chief iron bearing minerals with traces of goethite, martite and limonite. Quartz was the chief non-metallic gangue. Metallics and gangue were liberated below 150 mesh size.

### Sample No. $C_1$

Complete chemical analysis of the sample was given below :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 29.82 | S | 0.025 |
| $Fe_3O_2$ | 41.90 | LOI | 0.91 |
| FeO | 0.95 | MgO | Trace |
| $SiO_3$ | 55.60 | CaO | Trace |
| $Al_3O_2$ | 0.53 | Mn | Trace |
| P | 0.13 | $TiO_2$ | Trace |

Davis tube tests with 65, 100, and 150 and 200 mesh feeds produced concentrates varying from 55% Fe, 56.4% Fe, 58.73% Fe and 61.0% Fe respectively. Distribution of iron varied from 40.7% with 65 mesh feed to 48.0% in case of 200 mesh feed.

Tabling at 65 mesh followed by grinding to 200 mesh and high intensity magnetic separation produced a concentrate analysing 63.3% Fe with 56.0% Fe distribution ; flotation tests with 70% —200 mesh grind after desliming produced a concentrate (Sulphonate as collector) analysing 60.5% Fe with 22.3% Fe distribution in it.

### Sample No. $B_1$

The sample analysed as given below :

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 28.19 | S | 0.020 |
| $Fe_2O_3$ | 38.84 | LOI | 1.29 |
| FeO | 1.30 | MgO | 0.25 |
| $SiO_2$ | 57.20 | CaO | Trace |
| $Al_2O_3$ | 0.92 | Mn | Trace |
| P | 0.026 | $TiO_2$ | Trace |

Magnetic separation tests at 65, 100, 150 and 200 mesh size yielded concentrates assaying 53.86% Fe 56.4% Fe, 60.5% Fe and 60.8% Fe respectively while the Fe distribution ranged from 28.8% with coarse grind to 33.7% with fine grind.

Tabling at 65 mesh followed by regrinding to 200 mesh and magnetic separation yielded concentrate assaying 62.7% Fe with 50.1% Fe distribution. Sulphonate flotation resulted in a float with a grade of 59.5% Fe and 29.2% Fe distribution.

**Sample No. $B_{11}$**

The sample had the following chemical composition.

| Constituent | Assay % | Constituent | Assay % |
|---|---|---|---|
| Fe | 30.47 | CaO | 0.56 |
| $Fe_2O_3$ | 43.53 | P | 0.03 |
| FeO | 1.40 | S | 0.56 |
| $SiO_2$ | 52.71 | LOI | 0.323 |
| $Al_2O_3$ | 1.64 | $TiO_2$ | Trace |
| MgO | 0.17 | Mn | Trace |

High intensity magnetic separation tests with 65, 100, 150 and 200 mesh feeds produced respective concentrates assaying 56.5% Fe, 60.58% Fe, 62.18% Fe and 63.5% Fe while the Fe distribution varied from 35.7% to 34.5% (decreased).

Tabling tests at 65 mesh followed by regrinding to 200 mesh and magnetic separation produced a concentrate assaying 67.45% Fe with 56.1% Fe distribution.

Sulphonate flotation resulted in a concentrate of 60.8% Fe grade with 21.0% Fe distribution in it.

It may be noted that these three samples are reported to be taken from the surface of the deposit. It may be likely that the ore available at depths may have better amenability to beneficiation, thereby yielding concentrates with higher iron recoveries.

Condensed results of the various samples treated are given in Table 2.39.

**Table 2.39—Summary of the Results of Beneficiation Studies on Iron Ore Samples from Rajasthan, Maharashtra, Goa, Andhra Pradesh, Tamil Nadu, Assam, Karnataka, Uttar Pradesh etc.**

| Sample/Locality | Assay % | Treatment/Processing | Concentrate | |
|---|---|---|---|---|
| | R.O.M. sample | | Assay % | Recovery % |
| (1) | (2) | (3) | (4) | (5) |
| **Rajasthan** | | | | |
| (1) Darlamata Iron Ore | Fe=40.8; $SiO_2$=40.37 $Al_2O_3$=0.8 | Tabling at —48 mesh after hydro-classification | Fe=65.8 $SiO_2$=3.8 | Fe=79.4 |
| | | Magnetic Separation | Fe=60.48 $SiO_2$=12.57 | Fe=70.0 |
| | | Reduction Roast and Magnetic separation | Fe=64.48 $SiO_2$=8.37 | Fe=90.0 |
| | | High tension Separation at —48 mesh | Fe=64.59 $SiO_2$=6.0 | Fe=72.4 |
| | | Flotation (fatty acid) | Fe=63.27 | Fe=64.7 |
| | | Flotation petroleum Sulphonate and $H_2SO_4$ | Fe=64.07 $SiO_2$=8.13 | Fe=82.3 |
| (2) Amsiwali Iron Ore | Fe=49.85 $SiO_2$=27.82 $Al_2O_3$=0.38 | Tabling at 65 mesh | Fe=67.0 | Fe=86.0 |
| | | Spiral and Tabling | Fe=66.74 | Fe=85.6 |
| | | Magnetic separation at 65 mesh size | Fe=62.3 | Fe=85.3 |
| | | Reduction roast and magnetic separation | Fe=66.73 | Fe=98.2 |
| | | Flotation (fatty acid) and cleaning | Fe=65.72 | Fe=85.8 |
| | | Flotation Sulphonate | Fe=66.4 | Fe=90.3 |
| (3) **Khursipar Iron Ore** | Fe=55.7; FeO=6.5; $TiO_2$=15.11; $SiO_2$=2.1 $Al_2O_3$=1.05 | Magnetic separation at 100 mesh | Fe=60.82 $TiO_2$=9.38 | Fe=79.5 |
| (4) **Surajagar Iron Ores** (i) Massive (ii) Laminated (iii) Float ore | Hematite in predominance with minor goethite, silica and aluminous minerals | Crushing strength and reducibility tests were conducted. | | |

**Table 2.39** (*Contd.*)

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| (5) **Lohara Iron Ore** | | | | |
| (i) Main ore body | Fe=66.5; FeO=6.3; $SiO_2$=0.74; $Al_2O_3$=1.2 | Magnetic separation Davis Tube Tests, —48, 65 & 100 mesh | Fe=66.4—67.2 | Fe=70.0 |
| (ii) Stock sample | Fe=65.25; FeO=7.2; $SiO_2$=1.92; $Al_2O_3$=1.2 | Davis Tube Tests, —48, 65 & 100 mesh | Fe=67.34—67.8 | |
| **Goa Iron Ores** | | | | |
| (6) Pale Iron Ore | Fe=60.5; FeO=2.55; $SiO_2$=4.53; LOI=6.47 $Al_2O_3$=3.91 | Washing, Cycloning | Fe=64.3; $SiO_2$=2.76 $Al_2O_3$=2.25 | Fe=93.6 Pelletization tests also done |
| | Hematite, Goethite, Ochre, Quartz, | Magnetic separation | Fe=67.13 | Fe=57.1 |
| (7) Sesa Goa Iron Ore | Fe=55.5; $SiO_2$=2.72 $Al_2O_3$=11.17; LOI=6.9 Lateritic ore | Washing wet screening classifying | Lumps (washed); —30+18 mm | Fe=29.1 |
| | | | Fe=61.6; $SiO_2$=1.1 $Al_2O_3$=7.64 | |
| | | | —18+6 mm : Fe=56.9 | Fe=31.3 |
| | | | —6 mm : Fe=56.5 | Fe=26.7 |
| | | HMS of —30+18 mm lumps | Fe=63.3; $SiO_2$=0.86 $Al_2O_3$=6.1 | Fe=22.8 |
| | | Jigging of —18+6 mm lumps | Fe=62.7; $SiO_2$=1.2 $Al_2O_3$=6.67 | Fe=27.5 |
| | | Jigging —6 mm | Fe=61.56 | Fe=19.0 |
| | | Combined Conc. | Fe=62.5; $SiO_2$=1.26 $Al_2O_3$=6.6 | Fe=69.3 |

| Codli (Goa) Iron Ores : M/s. Min Goa (P) Ltd. | Fe | $SiO_2$ | $Al_2O_3$ | | Fe% | $SiO_2$ | $Al_2O_3$ | Fe% |
|---|---|---|---|---|---|---|---|---|
| Lumpy Ore | 51.3 | 5.0 | 12.9 | Crushing to —30 mm, Washing and screening. | | | | |
| Fines Ore | 53.0 | 6.9 | 9.3 | | | | | |
| Goethite, lateritic and other iron oxides | | | | +10 mm washed lumps | 53.2 | | | 48.4 |
| | | | | —10 mm sand | 51.5 | | | 35.3 |
| | | | | Heavy Media Separation at 2.9 sp. gr. of lumps | | | | |
| | | | | Sink | 59.9 | | | |
| | | | | Float | 48.3 | | | |
| | | | | —10 mm sand Wet. screening on 1 mm screen | | | | |
| | | | | +1 mm sand | 50.4 | | | 64.5 |
| | | | | —1 mm sand | 56.0 | | | 31.2 |
| | | | | HMS Tests With +1 mm sand at sp.gr.=2.9 | | | | |
| | | | | Sink | 61.1 | 2.8 | 7.0 | |
| | | | | Tabling of —1 mm washed sand after sizing at 65 mesh and tabling combined conc. | 65.9 | | | 53.9 w.r.t. —1 mm sand |
| | | | | Humphry's spiral test with —1 mm sand ground to —28 mesh | 63.0 | | | 54.9 |
| | | | | Grinding of —10 mm fines to —10 mesh, hydrosizing and tabling conc. | 60.7 | | | 18.0 |

**Table 2.39** (*Contd.*)

| (1) | (2) | (3) | (4) | | | (5) |
|---|---|---|---|---|---|---|
| | Fe $SiO_2$ $Al_2O_3$ | Crushing, Washing and Screening | Fe% | $SiO_2$% | $Al_2O_3$% | Fe% |
| Codli (Goa) Iron Ores | Fines | | | | | |
| | Sample 53.0 6.9 9.3 | +10 mm lumps | 59.9 | | | 25.1 |
| | | —10 mm fines | 57.7 | | | 42.8 |
| | | H.M.S. of +10 mm lumps | | | | |
| | | Sink | 63.4 | | | |
| | | Float | 56.3 | | | |
| | | Wet. Screening of —10 mm fines on 1 mm screen | | | | |
| | | H.M.S. of +1 mm of 2.9 | | | | |
| | | Sink | 59.9 | | | |
| | | Tabling of —1 mm fines at —48 mesh | | | | |
| | | Table Conc. | 66.2 | 1.61 | 2.1 | 74.0 |
| | | Spiralling of —1 mm fines conc. | 66.1 | 1.0 | 2.4 | 61.7 |
| | | Washing of —10 mm sand ground to —48 mesh tabling concentrate | 64.7 | | | 62.6 |
| | | Slimes-cyclone underflow | 51.8 | | | |
| | | Lumpy Ore : | Fe% | $SiO_2$% | $Al_2O_3$% | Fe% |
| Codli (Goa) Iron Ores | High grade lumpy ore { Fe=57.4, $SiO_2$=3.5, $Al_2O_3$=6.9 | Crushing to —30 mm, Washing and sizing on 10 mm screen | | | | |
| (Pilot Plant Studies) | High grade Fines { Fe=61.6, $SiO_2$=3.3, $Al_2O_3$=4.5 | +10 mm lumps | 59.9 | 2.1 | 6.5 | 38.0 |
| | | —10 mm lumps | 58.8 | 3.1 | 6.4 | 38.2 |
| | | Fines : | | | | |
| | | +10 mm washed lumps | 63.5 | 2.5 | 3.0 | 22.7 |
| | | —10 mm sand | 63.3 | 2.8 | 3.2 | 43.7 |
| | | H.M.S. of +10 mm lumps at sp.gr. 2.9 | | | | |
| | | Sink | 62.1 | 1.8 | 5.8 | |
| | | Fines lumps Sink | 64.9 | 1.5 | 2.0 | |
| | | Wet screening of —10 mm on 1 mm screen | | | | |
| | | Lumps : Coarse fraction | 56.0 | | | |
| | | Finer sand | 63.0 | | | |
| | | Fines : Coarse fraction | 63.4 | | | |
| | | Finer sand | 64.4 | | | |
| | | H.M.S. of +1 mm coarse sand sp.gr. 2.9 | | | | |
| | | Lumps Sink | 68.5 | 2.5 | 6.0 | |
| | | Fines Sink | 64.77 | 1.8 | 2.2 | |
| | | Spiralling of —1 mm sand at —28 mesh | | | | |
| | | Lumps concentrate | 65.4 | 1.5 | 2.9 | |
| | | Fines concentrate | 65.7 | 1.6 | 1.6 | |
| | | Slime-cyclone underflow | | | | |
| | | from lumps | 61.9 | | | |
| | | from fines | 61.6 | | | |
| Girar Iron Ores—Jhansi Dist. | Sample $C_1$ | Magnetic separation in Davis Tube | | | | |
| Department of Mines & Geology, Uttar Pradesh, Government | Fe=29.82, $SiO_2$=55.6, FeO=0.95 | With —65 mesh | Fe=55.0 | | | Fe%=40.7% |
| | | With —200 mesh | Fe%=61.0 | | | Fe%=47.0 % |
| | | Tabling at —65 mesh followed by grinding of Conc. to —200 mesh and magnetic separation | Fe%=63.3 | | | Fe%=56% |
| | | Flotation after desliming feed 70%—200 mesh Using sulphonate collector | Fe%=60.5% | | | Fe=22.3 |

**Table 2.39** (*Contd.*)

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| | Sample $B_1$<br>Fe=28.19<br>$SiO_2$=57.2<br>FeO=1.30 | Magnetic separation<br>at —65 mesh<br>at —200 mesh<br>Tabling at —65 mesh followed by magnetic separation at —200 of table conc. | Fe=53.86<br>Fe=60.9<br>Fe=62.7 | Fe=28.8<br>Fe=33.7<br>Fe=50.1 |
| | Sample B II<br>Fe=30.47<br>$SiO_2$=52.71<br>FeO=1.40 | Magnetic separation<br>at —65<br>at —200 | Fe=56.5<br>Fe=63.5 | Fe=35.7<br>Fe=34.5 |
| The above samples were surface samples only | | Tabling at —60 mesh followed by magnetic separation of table conc. at —200 mesh | Fe=67.45% | Fe=56.1 |
| **Andhra Pradesh Ores** | | | | |
| 8) Ongole Iron Ore | Fe=32.6; FeO=5.4<br>$SiO_2$=49.9<br>$Al_2O_3$=2.2<br>Magnetite, Goethite, hematite Quartz | Magnetic separation<br>at —48, —65<br>Tabling at —48,<br>—65<br>Magnetic separation followed by tabling of non-mag.<br>Magnetic separation followed by cycloning of non-mag<br>Reduction roast and magnetic separation at —100 | Fe=53.8<br>Fe=59.8<br>Fe=63.8<br>Fe=65.9<br>Fe=62.42<br>Fe=63.93<br>Fe=64.7 | Fe=49.9<br>Fe=74.3<br>Fe=51.9<br>Fe=57.8<br>Fe=83.4<br>Fe=83.4<br>Fe=80.9 |
| **Tamil Nadu Ores** | | | | |
| 9) Salem Magnetite No. 1 | Fe=36.5; FeO=5.04;<br>$SiO_2$=44.2<br>$Al_2O_3$=1.92<br>Magnetite, hematite, Quartz, etc.<br>—48 mesh liberation | Dry magnetic separation<br>at —35, —48<br>Wet magnetic separation<br>at —48, —65<br>Tabling at —48<br>spiralling at —48<br>Pilot Plant Tabling —48 mesh<br>Pilot Plant Magnetic separation —100 mesh | Fe=60.34<br>Fe=61.7<br>Fe=62.5<br>Fe=64.3<br>Fe=65.2<br>Fe=62.0<br>Fe=67.0<br>Fe=62.1 | Fe=71.9<br>Fe=72.0<br>Fe=88.9<br>Fe=83.6<br>Fe=85.8<br>Fe=73.3<br>Fe=77.6<br>Fe=81.2 |
| | Sintering studies with the concentrate conducted to produce self-fluxing sinters. | | | |
| (10) Salem Magnetite No. 2 | Fe=36.51<br>$SiO_2$=44.88<br>$Al_2O_3$=1.36 | —65 mesh optimum Grind<br>Batch magnetic separation | Fe=64.0 | Fe=86.3 |
| 160 tonne sample Pilot Plant Studies | | Pilot Plant Run | Fe=65.62 | |
| | | Feed=88.7% —200 mesh and magnetic separation and tabling of non-mag.<br>Cleaning of Mag. Conc. | Fe=66.8<br>Combined conc. = Fe=65.64<br>Fe=70.4 | Fe=91.5<br>Fe=88.8 |
| (11) Salem Magnetite Sample No. 3 | Fe=37.0;<br>$SiO_2$=47.0;<br>$Al_2O_3$=0.8 | —100 mesh liberation. Magnetic separation and Tabling | Fe=67.51 | Fe=88.0 |

**Table 2.39** (*Contd.*)

| | | | | |
|---|---|---|---|---|
| (12) Kavuthumalai Magnetite sample —C | Fe=34.6; $SiO_2$=43.57 FeO=4.47 $Al_2O_3$1.0 | Wet magnetite separation at —65 mesh and cleaning | Fe=68.4 | Fe=88.5 |
| Martite, Magnetite, Goethite, Quartz, Grunerite | | Continuous Wet magnetic separation at —10 mesh followed by grinding to 60 mesh and cleaning | Fe=63.15 | Fe=91.43 |
| | | Tabling at —48 | Fe=67.17 | Fe=57.15 |
| | | Spiralling at —48 | Fe=57.25 | Fe=81.38 |
| (13) Kavuthumalai Magnetite Sample-M | Fe=34.51 FeO=5.69 $SiO_2$=45.97 $Al_2O_3$=1.05 | Liberation 65 mesh Magnetic separation —10 mesh followed by regrinding the conc. to —65 and magnetic separation and cleaning of tails on | Fe=64.2 | Fe=91.16 |
| | | Tabling at Wet magnetic separation at 65 mesh and cleaning | Fe=65.52 | Fe=62.65 |
| | | Continuous Tests : Mag. Separation —10 mesh followed by 65 mesh cleaning | Fe=65.37 | Fe=90.92 |
| | | Direct —65 mesh cleaning | Fe=64.59 | Fe=85.5 |
| | | | Fe=66.06 | Fe=85.18 |
| (14) Kavathumalai Magnetite Sample-F | Fe=31.63 FeO=2.23 | Wet magnetic separation at —10 mesh followed cleaning at —65 mesh | Fe=56.1 | Fe=89.41 |
| | | Magnetic Separation at | Fe=62.75 | Fe=91.26 |
| Liberation at 100 mesh Mineralogy same as other samples C and M | $SiO_2$=48.0 $Al_2O_3$=1.38 | After one cleaning —100 | Fe=63.7 | Fe=88.55 |
| | | —100, —150 | Fe=63.8 | Fe=84.72 |
| | | Continuous magnetic separation at —35 mesh followed by regrinding and cleaning at —100 mesh | Fe=63.43 | Fe=86.23 |
| | | Recleaning at 150 mesh | Fe=64.85 | Fe=85.09 |
| | | Magnetic separation at —10 mesh followed by grinding and magnetic separation at —100 mesh and cleaning | Fe=64.23 | Fe=82.85 |
| (15) **Assam Iron Ore** | Fe=46.45; FeO=4.41; $SiO_2$=32.0; $Al_2O_3$=6.6 | Tabling at 48 mesh after sizing | Fe=66.89 | Fe=89.3 |
| | Hematite and Quartz Liberation at 48 mesh | Spiralling and Tabling | Fe=66.83 | Fe=91.0 |
| | | High tension separation | Fe=67.71 | Fe=62.1 |
| | | Flotation (Sulphonate) | Fe=67.4 | Fe=93.4 |
| Chandradinga Iron Ore Assam State Geology Dept. | Iron ore Assay% Fe $SiO_2$ $Al_2O_3$ 44.24 1.71 32.42 | Beneficiation and agglomeration | Fe% | Fe% |
| | | Tabling at —28 mesh | 62.72 | 77.9 |
| | | Tabling at —35 mesh | 62.72 | 82.0 |
| | Magnetite, hematite, martite, Quartz | Tabling at —48 mesh | 63.96 | 81.6 |
| | | Tabling at —65 mesh | 64.52 | 79.0 |
| | | Spiralling at —48 mesh | 62.71 | 77.1 |
| | | Wet Magnetic separation | | |
| | | at —48 mesh | 61.04 | 35.0 |
| | | at —65 mesh | 61.48 | 38.0 |
| | | Sulphonate flotation conc. | 50.98 | 73.3 |
| | | Pelletisation of the table concentrate | | |
| | | Pellet feed=70% —325 mesh | | |

Table 2.39 (*Contd.*)

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| | | Bentonite=1%<br>Limestone=8%<br>The compressive strength of the pellets after heat hardening was 325 kg/pellet | | |
| **Karnataka Ores** | | | | |
| (16) Kudremukh No. 1 | Fe=42.7; FeO=4.34<br>$SiO_2$=36.3; LOI=2.71<br>$Al_2O_3$=1.06 | Tabling at 48 mesh after sizing | Fe=63.66 | Fe=71.7 |
| | | Tabling at 100 mesh | Fe=63.63 | Fe=62.1 |
| | | Spiralling and tabling | Fe=60.63 | Fe=73.2 |
| | Hematite, magnetite, goethite, Quartz | Magnetic separation at | Fe=62.77 | Fe=49.3 |
| | Liberation 100 mesh | 65 and 100 mesh size | Fe=64.57 | Fe=45.5 |
| | | Magnetic separation and flotation | Fe=62.9 | Fe=90.1 |
| **Donimalai Iron Ores** | | | | |
| (17) Sample Type 2 | Fe=65.0; $SiO_2$=1.9<br>$Al_2O_3$=2.6; LOI=1.5 | Washed lumps | Fe=67.5<br>$SiO_2$=2.0<br>$Al_2O_3$=2.0 | Fe=73.9 |
| | Washing tests | Classifier sand | Fe=66.1<br>$SiO_2$=0.8<br>$Al_2O_3$=2.6 | Fe=18.6 |
| | | Cyclone conc. | Fe=56.4 | Fe=4.5 |
| (18) Sample Type 3 | Fe=66.0; FeO=1.1<br>$SiO_2$=1.1; LOI=1.7<br>$Al_2O_3$=2.6 | Washed lumps | Fe=67.4<br>$SiO_2$=0.8<br>$Al_2O_3$=1. 6 | Fe=61.0 |
| | Washing tests | Classifier sand | Fe=66.0<br>$SiO_2$=1.2<br>$Al_2O_3$=2.1 | Fe=29.6 |
| | | Cyclone Conc. | Fe=60.8 | Fe=5.4 |
| (19) Sample Type 4 | Fe=64.7; FeO=Tr.<br>$SiO_2$=2.3; LOI=2.4;<br>$Al_2O_3$=2.8 | Washed lumps | Fe=66.9<br>$SiO_2$=1.6<br>$Al_2O_3$=2.1 | Fe=56.8 |
| | Washing Tests | Classifier sand | Fe=64.7<br>$SiO_2$=2.1<br>$Al_2O_3$=2.6 | Fe=28.6 |
| | | Cyclone Conc. | Fe=61.1 | Fe=8.8 |
| (20) Sample Type 5 | Fe=65.5; FeO=1.7<br>$SiO_2$=2.3; LOI=2.4<br>$Al_2O_3$=2.7 | Washed lumps | Fe=68.1<br>$SiO_2$=1.1<br>$Al_2O_3$=1.7 | Fe=46.6 |
| | | Classifier sand | Fe=67.5<br>$SiO_2$=1.8<br>$Al_2O_3$=2.2 | Fe=36.2 |
| | | Cyclone Conc. | Fe=60.7 | Fe=11.2 |
| (21) Sample Type 6 | Fe=65.8; FeO=Tr.<br>$SiO_2$=1.8; LOI=1.5<br>$Al_2O_3$=2.7 | Washed lumps | Fe=66.7<br>$SiO_2$=1.4; $Al_2O_3$=1.9 | Fe=20.5 |
| | | Classifier sand | Fe=66.6<br>$SiO_2$=1.5; $Al_2O_3$=1.8 | Fe=55.9 |
| | Washing Tests | Cyclone Conc. | Fe=65.1 | Fe=12.4 |
| Kudremukh Iron Ore Mines MECON-Ranchi Magnetite concentrate for Pelletisation Studies | Concentrate: Fe 67.9, $SiO_2$ 2.9, $Al_2O_3$ 1.00, FeO 19.2<br>—28 mesh size | Optimum size for Pelletisation 65% —325 mesh.<br>Bentonite—0.5%-1.0%<br>Moisture—5-6% | Heat hardened Pellets compression strength 265 kg/pellet<br>Analysis: Fe 67.2, $SiO_2$ 3.1, $Al_2O_3$ 0.8, FeO 0.5 | |

**Table 2.39** (*Contd.*)

| | | | | |
|---|---|---|---|---|
| Kemmangundi Iron Ore | Fe $SiO_2$ $Al_2O_3$ | Crushing, washing and screening. | | |
| | 60.81 1.65 5.24 | —50+12 mm lumps | Fe=63.2 | Fe=47.0 |
| Mysore Iron & Steel Ltd. | Composite Blend Sample of Laminated, lateritic, limonite and blue dust types | —12+6 mm lumps | Fe=61.5 | Fe=12.7 |
| | | —6 mm sand | Fe=60.9 | Fe=15.2 |
| | | Cyclone underflow of the slime | Fe=59.2 | Fe=14.3 |
| | | Sintering of —12 mm including clf. sand using limestone, dolomite, coke breeze, lime sludge. | (Fe=60.0) ($SiO_3$=1.7) ($Al_2O_3$=5.3) | |
| | | Optimum conditions of sintering Water=7% Coke Breeze=6% Return Fines=25% | | Self fluxing sinters were made with a basicity ranging 1.0-3.0. Which require a higher coke breeze when the basicity was 2.0 and above. |

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